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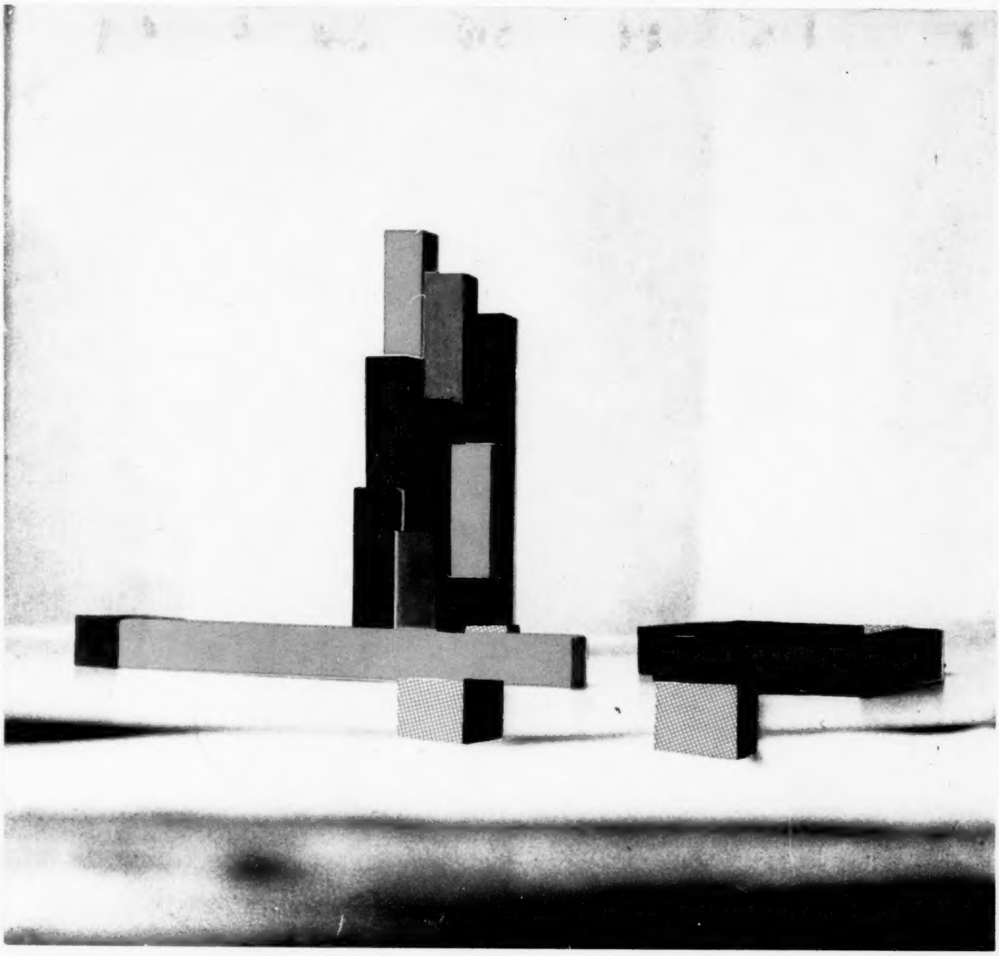
MAIN CURRENTS IN MODERN THOUGHT



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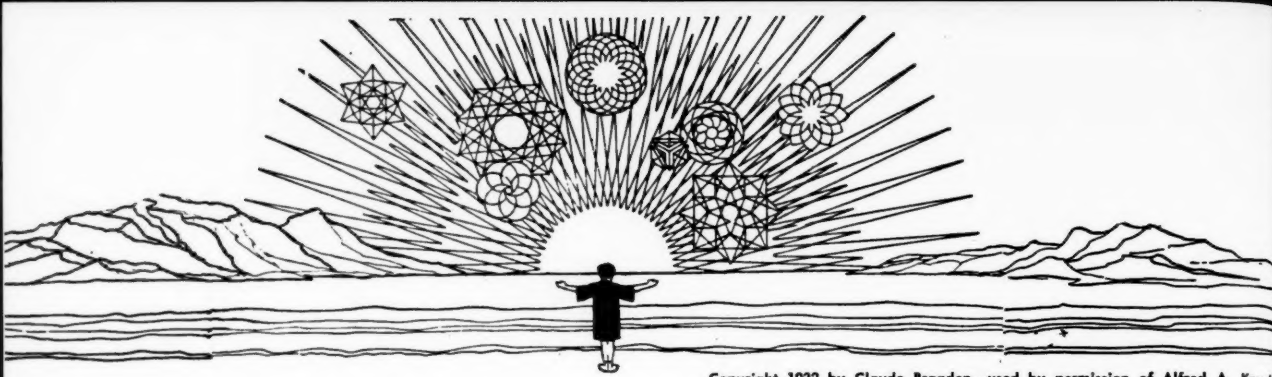

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MAIN CURRENTS
IN MODERN THOUGHT

A cooperative journal to promote the free association of those working toward the integration of all knowledge through the study of the whole of things, Nature, Man, and Society, assuming the universe to be one, dependable, intelligible, harmonious.

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The cover illustrates a haphazard grouping of the Cuisenaire blocks.

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MAIN CURRENTS IN MODERN THOUGHT is published to call attention to significant contributions to learning currently being made in the multiple fields, relating these advances to each other and to classical and contemporary views of Eastern, European and American thinkers. It is designed to save time for the reader by providing a vantage-ground from which the whole world of knowledge may be surveyed and kept in proportion as it moves toward integration. Its editors assume that the principles of art, the universals of philosophy, the laws of Nature and Man as formulated by science, and the truths of comparative religion, can be orchestrated into a harmonic, meaningful, ethical body of teachings which can and should be made the central core of curricular study in the educative process at all levels. Contributors to MAIN CURRENTS enjoy full liberty of opinion and expression in these pages.
In condensing text, square brackets [ ] indicate editorial interpolation. Three dots . . . indicate a word, phrase or passage omitted.

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THE CUISENAIRE DISCOVERY

C. Gattegno

Notes on a Radical Transformation in the Teaching of Mathematics

IN a world that has undergone such great technological changes in so short a time we are confronted by pressing questions in the field of education. Can we afford to continue to use ways of teaching which arose in medieval Europe and were essentially derived from the Greeks and the Jesuits? Why has teaching remained so close to the ancient pattern when education, in the hands of great pioneers, has shown infinite possibilities of growth? Improvements in classroom design and in school buildings, the lavish use of color in school text-books, make only a surface contribution to the real challenge, which is that of creating a generation of young men and women who are at the same time competent, socially integrated and free in spirit.

The methods we have inherited in the West succeed in making the intellect sharper and more penetrating, but they fail to provide a succession of springboards by means of which the mind can become ever freer of the restrictions it meets. The old methods are directed towards disciplining the mind; what is needed today is an education that leads to greater awareness of what constitutes the mind and of how to master the dynamics of thought, of the emotions and of creativeness. We propose here to discuss this radical transformation in the aim of education in relation to the strictest of all subjects: mathematics, and to do so in practical terms. This discussion is most relevant to the situation in which education finds itself today. We may note that in the only country, i.e. the United States, where it was permissable for school children not to take mathematics as a school subject, the clamor for more mathematics is now loudest. But in other countries too the small percentage of those who benefitted from their mathematical studies posed a very serious problem to educators and administrators. It seems thus that the pedagogical question confronting all the Western nations today has two sides to it: one concerned with teaching methods that would perhaps permit that more and more children acquire more and more mathematics, and the other concerned with what sort of mathematics to teach in our present world, so full of complicated challenges.

IT is our intention to examine the techniques of the process by which greater mastery and freedom in mathematics can be achieved by all children to whom the opportunity is given. But first we should emphasize that mathematics has a unique role to play in education, because its main function is to prepare everyone who cares to acquire its techniques for the job of making mental models of situations, including in them the most relevant data, and deducing from these models conclusions that were hidden but which are needed in order to forge ahead. In brief, mathematics is much more than a tool for calculating one's pay envelope, one's tax situation, or one's profit ratio. It is a power given to the individual so that he can find more in what he meets. This power is a birthright of every one of our children, and schools should make it accessible to all.

Before entering into details, we must familiarize the reader with certain concepts that are essential in our thinking, one of which is the concept of *dialogue* between the mind and reality, (the latter including the subject himself as a consciousness). It is in the confrontation of the whole of the mind, mobilizing the energies of spirit, with situations met, that growth in awareness and knowledge takes place. It is obvious that when alert minds meet the same situation (roughly defined) they find in it things that are different. This could not be so without the presence of a third term which is made patent by what we have called the dialogue: the mind and the situation engage in an intercourse in which both play a part. When the situation is not external, but involves the content of the mind itself, there is still dialogue, within the mind itself, and learning is then the deepening of awareness. The situation is shared, but since minds vary, dialogues differ.

Since we consider *situations* as data, we need only say that a configuration, or a set of internal relations between things, people, events, forces, etc., is assumed when we speak of a situation. The configuration is natural to the situation and need not be specified, or even known, yet we all assent to it as implied and inevitable. Hence, it is a basic concept.

Without situations, taken in this sense, reality would be meaningless to the mind, and we shall assume that the meaning of both these words, situations and reality, is as intimately known to every reader as is the meaning of mind.

Growing up is the result of the use of time in successive dialogues between the mind and reality, and greater awareness of one's relation to reality is concomitant with mastery of skills. These skills are moreover the outcome of the dialogue to take place, and maintain in the proper channels the energy necessary to make them available. By looking we learn to look, by hearing to hear, by writing to write.

Thus we have a reality that is dynamic because it contains minds continuously engaged in changing themselves and in forming relations between themselves and the rest of reality. This reality can be envisaged as being composed of situations, and the learning process can be schematized as a dialogue of minds and situations, each changing the other.

Although in all its dialogues the mind is the same mind, some situations it meets may be mathematical. A new definition in psychological terms of the word mathematical is of essential significance here. Situations become mathematical, by definition, if the mind perceives in them *only* relationships, and ignores all the other possible attributes. But since relationships are met in situations, the mind is also aware of the various dynamics connecting these relationships. Mathematics is therefore the realm of experience in which what is contemplated, spoken of or written about, concerns relationships and their dynamics, entities being produced from time to time when the mind ceases to relate them to each other in order to move ahead. Objects are not the concern of the mathematician. When the word is used it refers to a class of unspecified things. $X=3$ is not a mathematical statement, although it is expressed in a notation created by the mathematician in order to meet his challenges. A mathematical statement is of the following type: "If we consider a class of relationships submitted to the effect of a relationship we find in the new situation the following relationships."

HAVING clarified our view of what constitutes the background of learning and of mathematics, we must now consider how our vision can be translated into a program of study for all pupils.

In our opinion, mathematics has never been taught in school. What has been taught is bits and pieces of knowledge, and it is matter for marvel that in spite of this fact some people have become mathematicians. It is not to be wondered at that the majority of our clever pupils understand nothing of the subject and quickly drop it. If they are to be won over to mathematics, all that is needed is that we expose them to true mathematics. Since mathematical activity is natural, there is no more reason to fail in it than in walking or talking, when the necessary mechanisms are present.

Our approach to the teaching of mathematics, then will be the following: we shall teach algebra before arithmetic, (the latter no longer being a collection of recipes for the solution of impractical problems, but the study of the properties of numbers), giving our pupils the full benefit of the thinking of the mathematicians of the last eighty years, and exposing them to structured fields of study. Thus the emphasis on Euclidean geometry will disappear, and the false sense of rigor which was considered to justify that study will be replaced by a progressive widening of the fields, a deeper understanding of the assumptions and clearer statements of the results obtained. With all this expressed in adequate notations, what the pupils produce looks singularly similar to what mathematicians publish. We shall have satisfied criteria which are at the same time psychological, pedagogical and mathematical—*and this is something new.*

WE must now justify our statement that algebra will be taught before arithmetic, and show how it can be done. Algebra is defined as the set of propositions that follow from the awareness of the effects of one or more laws of composition upon the elements of a set. An algebraic relation is one which substitutes for any two elements of a set another element of the set in certain conditions. Thus addition and multiplication are algebraic relations on the set of whole numbers.[1]

It is obvious that by giving children a set of objects upon which it is possible to define an operation we can enable them to discover what propositions follow from that simple fact. Fortunately for us, a Belgian teacher, Georges Cuisenaire of Thuin, has produced a set of colored rods such that the operation of putting them end to end is "isomorphic" with addition and a very large number of propositions can be obtained involving only equality of two lengths and the formation of any length by putting rods end to end, without any mention of numbers. This can be done with ease by children of five, and they have no doubts about the propositions obtained. For the mathematician this is algebra; for the child it is a meaningful game which can be varied indefinitely.[2]

Before describing the method of use we must first explain that the Cuisenaire rods are 1 sq. cm. in section, vary in length from 1 to 10 cm., and are colored according to a scheme developed after twenty-two years of experiment: 1 cm. white; 7 cm. black; 2, 4, 8 cms. varying shades of red; 3, 6, 9 cms. varying shades of blue; 5, 10, cms. varying shades of yellow. (See cover illustration.) This material represents a unique contribution to elementary mathematics learning.

Since color is an indication of a particular length, the set of rods contains sub-sets which are distinguishable by either color or length. The presence of a

[1]*Note*: Not all relations are algebraic; e.g. comparison of the magnitude of two elements, or the formation of ordered pairs, are not of that category.

[2]See *Arithmetic with Numbers in Colour.* Book 1, Part II.

double attribute in the set offers two terms of reference: a red and a yellow rod end to end are equivalent to a black rod, or to a blue-green and a pink end to end. This equivalence of lengths contains as a special case equivalence by color. But it can at once be seen that in terms of the operation of placing end to end, red and yellow is equivalent to yellow and red, and we thus discover a property of the operation (commutativity), or that any length can be formed of two or more rods (associativity). When several rods of the same color can be used to form a length, we can introduce a new arrangement of rods, side by side, and find that another operation (which can be called multiplication) has made its appearance. The relationship of these two operations is the distributive law of multiplication with respect to addition, and its inverse: factoring.

All this and much more becomes obvious through use of the rods. The knowledge of *how* things are done belongs essentially to the realm of the algebraist, and the early discovery by the pupils that the action of putting rods end to end does not depend on the particular rods, that the commutative law is inscribed in the patterns whatever the length, that associativity results from certain equivalences and not from the elements involved, plunges them from the start into this realm in which the tools are far more powerful and the mind is unrestricted by particular connections which must be memorized as such.

When the algebra of the set, and of the operations introduced and their inverses (when these can be defined) is thoroughly mastered (which takes a few weeks with children of five or six), comparison of the rods one with another will give rise to a new language for the propositions already encountered, and new properties will result from the new structures involved. It is the language of numbers, and we can now embark on the study of the set of rational numbers and their distinctive and important properties.

Here again, since we are concerned with psychological and pedagogical criteria at the same time as with mathematical rigor, we approach the study of numbers without prejudices: our pupils study the new properties which result from the new structures and use the algebra they have acquired in order to pass from one cardinal number to those that are linked with it within a certain range. The addition of 1 is not the key to the formation of the set of integers. This set is the union of all sub-sets that can be studied by all the means at our disposal. In particular, by using an operation such as doubling we produce subsets which are spread over the integers in a very different way from the uniform but uninteresting method of addition of 1.

In using our freedom with respect to the way we obtain the integers, we meet many more of their properties and the set of integers becomes more and more fascinating. Congruencies[3] emerge naturally at a very early stage and commutative rings[4] appear almost from the first, since so many examples are met. Composite and prime numbers are a matter of course and appear as naturally as counting disappears from the study of arithmetic.

A further important consequence is that the solution of problems is no longer sought by rule of thumb but by scrutiny of the structures involved, and the algebraic solution comes before the arithmetical one, as commonsense would suggest should be the case.

When algebra precedes arithmetic, freedom comes into its own and the affective straightjacket of discipline is forgotten. Elementary mathematics learning then serves the true education of the child. Because we use actual gestures upon actual objects and ask the appropriate questions, we give every child every chance to see, instead of leaving him to guess, what we mean.

BUT mathematics is not reducible to operations and numbers; there are its spatial aspects to be considered.

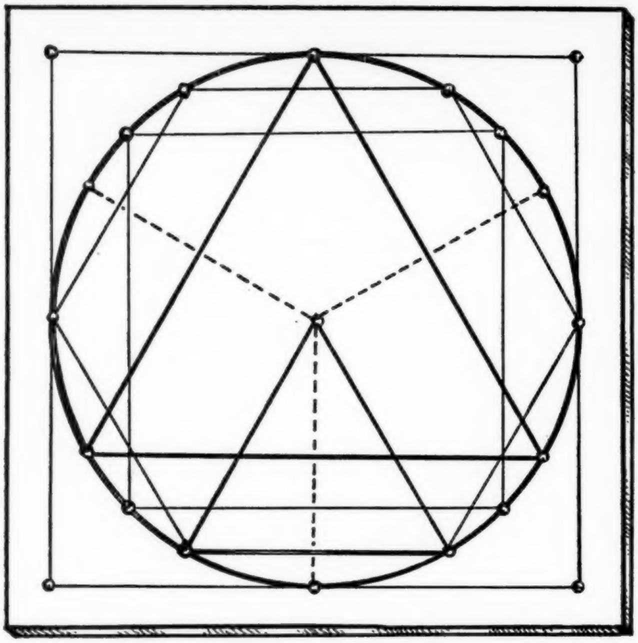
Here once again we must recognize that spatial relations are not all metric, and that we must first discover the structures which form the background of the mathematician's spatial judgements. Invariance and preservation of properties by certain transformations[5] have been studied by geometers, especially during the nineteenth century, and in 1874 Klein defined a geometry as a set of properties invariant with respect to a group of transformations. The simplest group is that of displacements, and Euclidean geometry is the system of properties of 2 or 3-dimensional sets invariant with respect to similitudes. Topological properties being involved in all spatial relations, it is now a platitude to suggest making our pupils aware of their presence as well as of other properties. As yet there has been no publication of any systematic presentation of spatial relations at the elementary level parallel to the one described above with respect to algebra and arithmetic. The writer is at present engaged on such a task and hopes soon to be able to publish the result of his work.

What has so far been developed is a study of finite geometry making use of the writer's Geo-Boards, which are finite lattices materialized by nails on boards on which colored rubber bands can be stretched. Since the boards can revolve and be moved about, the group of displacements affects all figures and properties. The main virtue of the Geo-Boards is that they provide a great variety of geometrical

[3]Two integers are congruent with respect to a third integer if they have the same remainder on division by the third; in particular they are congruent if they are both divisible by the third.

[4]A commutative ring is a set in which are defined the two commutative algebraic relations of addition and multiplication.

[5]As an example, in the deformation of a torus into a sphere with a handle, the fundamental characteristics of the torus (that it is a closed surface surrounding a single hole) are preserved, though metric properties, including shape, are drastically altered. Topology is the study of such invariant properties and of the transformations which leave them invariant.



Here is shown one of the geo-boards: arrays of nails defining fields of points set up upon basic figures such as the circle, the square, and so on. Colored rubber bands allow the child to move easily from figure to figure.

The board communicates, in experimental form and an atmosphere of play, a great variety of basic concepts which appear naturally in the child's mind. There is the notion of a lattice, for example, so fundamental to modern physical chemistry. Because the figure is movable, kinetic experience of rotation and translation is provided—two more ideas which go on to the end of the mathematician's life. Concepts like congruence, symmetry, etc., are brought forward into tactile as well as visual experience. As the rubber bands are moved, the child is in dynamic involvement with the material, not merely required to participate in a logical structure that proves so uninteresting (and even hateful) to many children, because it is so remote from experience.

situations, which can be investigated in the order which they are met, and not in the preconceived order of Euclid or his followers. Geometrical situations can be so easily produced that the 25-nail rectangular lattice already presents some hundreds of them. Although the Geo-Boards cover the investigation of metric spaces only, i.e. those studied in all schools, the few lattices needed have a valuable contribution to make towards *geometrical education* as opposed to geometrical conditioning.

In the attempt now being made by the International Commission for the Study and Improvement of the Teaching of Mathematics to re-write the whole of elementary mathematics for adolescents in the perspective of modern thought, we may find a first answer to the problem of substituting for the geometry which is at present supreme in mathematical education, truer mathematical thinking which consciously uses what is important in it and discards what is sterile. The work done in algebra and arithmetic for the first grades is most encouraging, and it is hoped that the secondary stages will be as effectively dealt with. The problem of teaching mathematics to all, in our highly technological age, will then be solved.

IT should be said in conclusion that those of us who are engaged in the radical transformation of mathematics teaching are making a wholesale attack on the problem and are seeking a solution that is applicable at all levels of learning. Aware that the wrong track has been followed for centuries only through ignorance of fundamental facts, and confident in the success already achieved, we look forward to the time, not too remote, when the only mathematics teaching problems will be new problems, the old ones either having proved to be only pseudo-problems or having been solved.

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Note: The series of "Arithmetic with Numbers in Colour" will be continued to Book X and should appear in sequence during 1958.
Many articles have appeared in several countries written by teachers on their experience. A number of controlled experiments are being carried out and preliminary reports are very favorable.

THE THIRD REVOLUTION AND THE FIFTH ESTATE

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The Destiny of the Egghead

PART II

Under the Sign of Sputniks

SINCE the publication of the first part of this article, certain important events have taken place that are relevant to our problem and cannot be left unmentioned. The events, of course, are the appearance of the artificial satellites and the reaction of the public mind to them. We all still live under the sign of Sputniks, and their impact upon our thinking is still gaining momentum, even if the intensity of the initial shock has been gradually subsiding.

As far as the problem of the brainworkers is concerned, the effects of the dramatic events has been beneficial: it brought to a focus the actuality of the Intellectual Revolution and the immediate value of scientists to modern society. Now it is hardly possible to dismiss the general consideration concerning the Third Revolution as abstract generalizations or academic speculations.

Every day, newspapers and broadcasts inform us of various discussions, plans and projects, all relating to the problem of how to produce for our society the necessary supply of scientists and teachers of science and mathematics. The efforts obviously are highly commendable, but as they are, they contain a hidden danger of oversimplifying the problem and paving the way for a nearsighted, superficial, and ineffective solution. To see the nature of this danger, it is necessary to examine the present crisis thoroughly.

The Three Shocks

MANY people would agree that within our memory this country has experienced three major shocks: the stock exchange crash of 1929, Pearl Harbor and the Sputniks. There are reasons to believe that the last shock has been the most significant.

The catastrophe of 1929 was the closest to all of us: the unemployed were sleeping in subways and selling apples in the streets, and almost every family suffered one way or another. But there was no element of puzzling novelty; the situation was one of those "business cycles," almost an expected phenomenon. Even if the view that "a depression lasts as long as a pair of pants" was a slick oversimplification, a business crisis *is* in a sense a self-liquidating process, as a phase of a cycle. Thus with the help of "bank holidays"—a hideous semantic contortion in itself—C.C.C. camps and pump-priming, the storm was weathered.

The Pearl Harbor explosions thundered far away, and while they spelled the calamity of a world war, they did not raise any bewildering or searching questions. There was only one possible course of action: to continue filling the Arsenal of Democracy with ammunition, and to build up the armed forces.

The Sputniks appeared in the stratosphere, and from there attacked us at the most sensitive point: they deprived the American people of its superiority in the field of "know-how." Know-how — in other words, technology, engineering, efficiency, mass production, and the abundance of various appliances, mechanism, tools and gadgets in every American home from the cellar to the attic and the roof—is the most treasured possession of American civilization. It is the quintessence of the American way of life. In the form of high standards of living, know-how has been one of the most effective weapons against criticism of American culture from without. The most significant contribution of America to world philosophy—pragmatism, which essentially is the evaluation of events by examining how they work and how well they solve the given problem in the given situation, rather than by analyzing what the events are—follows the know-how pattern and provides its theoretical justification.

No wonder that when the Sputniks deprived America of superiority in her own speciality, an enormous vacuum was created in the national self-esteem, which in turn produced a tremendous shock.

An argument can be advanced that the main reason for the reaction to the Sputniks is their military

significance. However, this does not seem likely. Sputniks hardly constitute any military danger directly, by themselves. They are dangerous only as symbol and evidence of the existence of other, more dangerous missiles. But even so, had we maintained our technical superiority, there would be no reason for our present distress, since nothing would prevent us from quickly rectifying the situation. The fundamental cause of the prevailing dismay and anxiety is undoubtedly the loss of the familiar, reliable and powerful weapon in war and peace: our national superiority in know-how.

Know-How vs. Know-What

TO many of us, however, the situation appears even more grave and complicated. Appearance of the Sputniks has thrown a shadow of doubt on the priority of know-how as a method and a general orientation, and has set more correctly into perspective the relation between know-how and know-what, which is so important at the time of transition between industrial and intellectual revolutions. Industrialized society naturally has a predilection for know-how, but this is an emotional choice. Actually, know-what is the leader. To start with, logically and semantically it is obvious: you cannot know *how* to make boullabaisse unless you know *what* boullabaisse is. Nor can you teach calculus if you don't know what it is. Chronologically, the progress of science precedes the corresponding technology. Only after the development of the science of mechanics and the discovery of the main facts about the behavior of electricity did mechanical and electrical engineering become possible. The contrast becomes clear if we compare the engineer and the scientist. The fundamental function of the former is to produce certain changes in the environment that are favorable to humanity. The corresponding function of the latter is to observe the phenomena of nature, to describe them as accurately as possible, to understand and to explain them. The engineer is essentially a transformer of environment, and therefore the favorite son of the Industrial Revolution; the scientist is essentially a thinker, an intellectual *par excellence,* and therefore the high priest of the Intellectual Revolution, of which we are in the midst.

All this may look obvious, but the facts must be kept in mind and stated unequivocally in order to eliminate the danger of being confused and handicapped by the psychological inertia from the past, and the cultural lag in the transition from industrial to intellectual orientation. Even now, behind the shouts for "more scientists and science teachers," one can easily discern the old yearning for "bigger and better engineers." Not long ago under the impact of the Sputniks, some physicists and chemists were granted an increase in salaries, obviously because of their close kinship with engineers, but biologists were left to wait for their advancement until some other country should invent some kind of biological sputnik and deliver us another shock.

En passant it may be wise to mention that of course the discussion should not be interpreted as unfriendly to engineers, who are one of the most valuable assets of any society, or as a suggestion to replace technology by science; it is concerned only with establishing proper correlation and coordination between the two for the greater benefit of all of us.

What Should Be Done?

THE considerations presented above lead us straight back to our main problem: What should be done (Sputniks or no Sputniks) in this country or in any other to help the Fifth Estate acquire a position satisfactory for the brainworkers themselves, and most beneficial to society as a whole?

We may start with two important facts: First, a potential brainworker is a very rare commodity. Among children of eight to ten years, only a small percentage is capable of developing into a fullfledged brainworker. Second, even among this potential a considerable percentage does not mature, either because many gifted youths do not recognize their own capacities or because they have no opportunities for proper education. As a result, every year thousands of individuals possessing the most precious qualifications, that cannot be developed at will, are lost to our society. The first step therefore is to eliminate the loss. This is quite possible. With our extended school systems, growth of psychological counselling, and increasing use of modern tests, we can hunt out the potential brainworkers, and provide them with the necessary opportunities. It will require some organization and some expense, but in this area the question of cost should not even be considered. Even in terms of dollars and cents at present an investment in talented youth is the best possible financial operation. With thinkers of that caliber we can discover, invent and acquire everything important to our happiness and our survival, but without them we will lose what we already possess, and indeed may perish.

The next step is to provide the necessary education. Here obviously no detailed suggestions can be given, except to indicate that the development of potential intellectuals should not be handicapped or distorted by poor teaching, insufficiently equipped schools, and the necessity to share classes with students of lesser capacity. On the college level, in one way or another exceptional youths should be relieved of the financial burden that may interfere with their studies.

The last step is to provide after the completion of their education the conditions most favorable for their work. Here we must pay attention to a very encouraging fact: an intellectual essentially is a self-motivated functional unit. This means that an indi-

vidual becomes a scientist, for instance, because he has within himself the divine spark of curiosity, because observation, understanding and explanation of significant events give him a tremendous satisfaction. Other motives, which are sometimes ascribed to scientists and other brainworkers, such as financial considerations or the desire to serve humanity, are probably not a very decisive factor. If those who become scientists were guided by the desire for riches they certainly would enter business, or some other more lucrative profession. As for the welfare of humanity, in most cases a scientist, as well as any other thinker, cannot even imagine the effect of his discoveries. When Galvani investigated convulsions of the legs of freshly killed frogs when they touched certain metals, he could not have had the slightest inkling that his experiments would eventually lead to the marvels of modern transportation and communication, as well as thousands of electric appliances and gadgets—in other words, that they would be responsible for three-quarters of the amenities of modern civilization.

From the practical point of view, the main thing is to remove the obstacles that may impede the brainworker. He must enjoy the freedom to think, to question, to discuss and to write; he must be free from unnecessary pressures and have a certain amount of leisure for the development of his ideas. It would not be possible to measure by a time clock how long it took Newton to discover the law of gravitation or fix for Einstein a deadline to devise a theory of relativity. The brainworker must be free from financial worries and from too many distracting chores. He also must have the opportunity for a normal family life. At present, large percentages of young intellectuals cannot afford to marry, and if married, to have children. This restriction has, of course, a tremendous social significance since it prevents the probable carriers of favorable hereditary characteristics from putting them into circulation, and limits the opportunities for the transfer of desirable social inheritance from cultivated parents.

Last but not least on the list of important requirements is the proper social recognition of brainworkers. Unless this condition is fulfilled, other factors will be only partially operative. Nobody can do his maximum of creative work if he is not happy and at home in his community, or if he feels himself to be a member of a "queer" minority. Yet, this has unfortunately often been the lot of the egghead. The term alone carries the implications.

The conditions necessary for the proper functioning of brainworkers can be finally reduced to the following list: Freedom of thought (no license!); a minimum of comfort (no luxuries!); freedom from financial worries (no riches!); a certain amount of leisure (no idleness!); a good education for children (nothing fancy!); social recognition (no adulation!). Hardly anyone would quarrel with these desiderata, and society sooner or later will doubtless be forced to provide the conditions. But this may be a long, devious and painful process if the brainworkers themselves do not take an active part in it. No revolution can reach a successful conclusion without positive efforts on the part of the new estate.

How All the Desiderata Can be Attained

THIS necessary action by the eggheads must take the same form as the action of the previous estates. Three factors are essential in the process of the ascendance of an estate to power: awareness of the importance of the function performed; unity and organization; and the use of the function belonging to the estate in question. The military acquired and maintained predominance by brute force; civil rulers, by administrative and legislative measures; the bourgeoisie, by the use and control of capital; labor, by controlling mass production and by mass action, primarily through strikes. Brainworkers as yet possess no brute force, no political influence, no money, and cannot strike *en masse,* but they are experts in the art of communication and persuasion.

At present, due in particular to the tremendous development of media of mass communication—press, radio, movies and television—for which the eggheads are primarily responsible, the power of persuasion has reached extraordinary proportions. It penetrates every nook and corner of our lives, has thousands of faces and manifests itself in all possible shapes and forms: teaching, preaching, lecturing, institutional education on all levels and in all forms, social traditions and taboos, societies, associations, clubs, political parties, electoral campaigns, philosophies, creeds, aggressive ideologies, party lines, incessant propaganda, commercial advertising, the cold war, diplomatic representations, the summit conferences, etc., etc., not to mention plain, everyday conversations, discussions and arguments that mold and shape the opinions and minds of people. All this is a fertile field to brainworkers; their special ability to cultivate it gives them a most powerful weapon.

What shall they do? Using each and every opportunity in daily life, brainworkers must: 1) immediately start the energetic and persistent work of persuasion in favor of the fifth estate, explaining its function, its importance and the necessity of securing for it the opportunity to function in the most effective way; 2) recruit as many other persuaders as possible; 3) form centers, chapters, branches and other similar groups and consolidate them into larger and larger units, until national bodies are established and, finally, an international fraternity. If properly organized, enthusiastically supported and wisely led, such an organization can become a powerful force, beneficial both to the brainworkers and to all mankind.

This does not mean that persuasion could or should be the only weapon. At present, scientific and other intellectual accomplishments are usually granted pro-

fessional recognition only in the form of establishing the priority of a discovery or giving semi-official evaluation of the achievement. If these forms of appreciation were connected with something like patent rights, with corresponding royalties, they could become sources of considerable income, and be used also for the promotion of professional interests. With the growth of the brainworkers' eminence and the need for their services, even a direct influence on the organization of intellectual work and its remuneration would not be beyond the realm of possibility.

It is important always to keep in mind that the ascendance of an estate to power is not a one-way development. In the process, every estate not only changes its conditions of life, but also changes itself. The members of the third estate at the end of the eighteenth century in France were not at all like modern financial and industrial magnates, and the workers in the early days of the Industrial Revolution were quite different from the organized labor of today.

In the same way, the eggheads have to change themselves. They have to learn how to live and act outside the ivory towers of their studios, libraries and laboratories, to mingle with other people, and to be more human and humane. They must use their gifts for solving problems even outside their special fields, possess a keen sense of responsibility for the welfare of society as a whole, organize their convictions, make decisions, and be determined and firm. Without these qualities they cannot gain the desired social recognition, just as without the social recognition they cannot acquire these needed qualities.

Broader Issues

BESIDES the immediate benefit of solving many of our most pressing problems, the rise of brainworkers to prominence will exercise a powerful positive influence of a more general and comprehensive nature: it will transform our system of values.

Every estate shaped the values of its time by creating an idealized favorite type of personality. At the time of the predominance of the military, the stereotype was a feared strong man, aggressive, bold and fearless. Next, under the influence of the nobility of the robe, the ideal arose of an awe-inspiring ruler, the lord and master, powerful and dominating. The bourgeoisie created the image of the envied man, successful, shrewd and influential. And finally, labor introduced the cult of the average or common man, folksy and gregarious.

The fifth estate will not take the place of all its predecessors, but will constitute an addition to them. It will thrust into the limelight an esteemed expert, competent and effective, a man of exceptional mentality and creative ability. The new note perhaps will help to cure some of the negative aspects of mass civilization so characteristic of our time.

One of our most important problems is perhaps the elimination of the habit of taking averages as positive norms. When in an emergency, we look for the best surgeon, the best general, the best leader; we are not satisfied with an average man. Even for entertainment we want the best artists and musicians. Yet too many people point with pride and satisfaction to themselves as "an average man."

Another problem is the eradication of the purposeful distortion of truth in public life. Advertising and propaganda are two extremely powerful forces in our culture. They are twin brothers: advertising is commercial propaganda and propaganda is political advertising. They both systematically distort the truth, either by exaggeration of some elements of a situation or by presenting only a part of the whole picture. Their danger lies not so much in moral corruption as in the fact that they obscure reality, and thus prevent the adoption of an objective approach and sane behavior. In the best organized branch of brainwork—science—there is no place or hope of success either for advertising or for propaganda. The growth of the prestige of science will be a powerful antidote against these poisons in our social atmosphere.

A Glimpse Into the Future

HERE perhaps a word of warning to the eggheads is needed. The brainworker should not, of course, ever think of himself as the best or highest type of man, or believe that the Intellectual Revolution will achieve the final solution of all our problems. That would be a dangerous and absurd illusion. The Third Revolution and the fifth estate are of course not the final stage To indicate the possibilities ahead of us, let us take a look at the conceivable future by an imaginative extrapolation of the curve of the previous development.

If and when the brainworkers' era achieves an inexhaustible supply of power through atomic energy, unlimited production of goods by automation, international cooperation, and liberation from the danger of all-destroying war and from the economic burden of armaments, then there may arrive the next, or Fourth Revolution and the sixth estate: the Aesthetic Revolution and the Artist.

When human sensitivity, creative imagination and the sense of values are sufficiently aroused and developed, humanity will be ready for the final stage: the Fifth, or Religious, Revolution, and the seventh estate, the spiritual man, the complete man, who will integrate and synthesize the best achievements of all the previous estates, eliminate their weaknesses, and realize the blissful state of existence visualized and prophesized by the great spiritual leaders of mankind. The guiding inspirations of the two last Revolutions will be the vision of the creative man, imaginative and accomplished, and the image of a beloved saint, wise and enlightened. Only the ideal of a many-sided and many-colored personality, integrated and harmonious, can lead man on and on, without stifling his progress.

TOWARD A CLIMATE FOR CREATIVITY

Gustav J. Martin

A Director of Research in Bio-Chemistry Looks Toward Integrative Research

ABOUT a year ago I visited the Union of Soviet Socialist Republics. I am frankly nationalistic and I felt very proud as we flew from Paris to Prague in a DC-7. The friend with whom I was travelling and I discussed the ubiquity of American airplanes, which we thought was a function of the beauty and efficiency of their designs. We were pleased to think of these planes as an indication of the superiority of American achievement, and of the fact that they were used in so many foreign countries as an indication that this superiority was recognized.

At Prague we sustained something of a shock. There we changed to a power jet Soviet transport. The plane was perfectly beautiful, and could have been objected to aesthetically only on the ground of over-elegance of appointments. To this beauty was added real efficiency; we went from Prague to Moscow at a speed approaching that of sound. The trip was a revelation and would have been an unalloyed pleasure except that it rather shook our assumption of the superiority of American aircraft.

In subsequent days in Moscow I had the opportunity to see a great deal of the Soviet effort in scientific research. I was impressed by the personnel and by the equipment, but most of all, by the attitude underlying the work that was going on. There seemed to be an orientation not merely toward achievement but toward *creative* achievement. The Russian people seemed to take more pride in the mental accomplishments of their scientists than in the physical accomplishments of their athletes at the Olympic games. Creativity was esteemed for its own sake as a high form of endeavor.

That this general attitude has produced impressive results is a matter of record. Examples are not difficult to find, with the development of the inter-continental missile and the artificial satellite being perhaps the most outstanding. In both of these instances the Soviet Union has outstripped the United States. It is my opinion that this is due to a fundamental difference in the attitude of which I have been speaking. It is, in fact, my belief that the meaning of true scientific creativity, which has enabled the Soviet Union to make such tremendous strides, is not understood in the United States, and that the bulk of our achievement has been superficial and not of a fundamental nature.

IT is quite true, that, as a nation, we have done a splendid job technologically. We have made possible the extension to many of articles which had once been the luxuries of the few. We have, in the material sense, made an outstanding success. But analysis shows that success, on this basis, has been at the expense of real scientific creativity.

Examples of what I mean can be adduced from every field of scientific endeavor. In the medical sciences, for example, we are in the era of "wonder drugs." To test the proposition that American science is essentially non-creative, I made a list of fifty of these "wonder drugs" selected at random. I then undertook to determine the country of origin of each material. For this purpose I disregarded analogs and homologs; valuable as these have been, they represent more or less routine work rather than genuine creativity. Sulfanilamide, for instance, was first made in Germany; this is the original molecule from which many others have been derived, and Germany is to be considered its point of origin. By the time my list was completed I found only one instance and a questionable second in which a "wonder drug" had had its origin in the United States. This is most certainly not due to the comparative youth of the country, since the drugs in question have almost all been created within the last twenty or thirty years.

I was shocked by this finding, and arranged for the preparation of a similar analysis of fundamental new ideas in the world of physics. The result was the same. Then, in the field of automotive engineering—a field in which one might expect the United States to be outstanding—a similar list was prepared. This produced the greatest shock of all: the fundamental

new contributions were not of American, but of European origin. In general it could be said that American automotive engineering was five to ten years behind the European achievement. It seems pointless to extend the analysis done in support of the conclusion that in the United States, creativity is indeed a scanty commodity.

In fact, one would not be distorting the case to state that Dr. Josiah Willard Gibbs, who created the world of thermodynamics, was virtually the one truly creative American scientist. I know that this statement will shock many, but it should. The thought that it is justified certainly shocked me. I repeat that I am by nature a nationalist and as such would much rather have things appear in a happier light. Nevertheless, they do not, and it becomes necessary to search for causes. There is doubtless more authoritative opinion to be found on these questions. The field is not even defined. Certainly I am not claiming to be an authority; but I do hope to stimulate detailed consideration of the problems which confront American science and American scientists.

THE first step toward correction of the situation is an endeavor to bring into the minds of educators and industrialists a recognition of the problem. The vast majority of such people have an inadequate concept of creativity. They tend to confuse it with minor intellectual exercise and technological developments. The popular press tends to build up the slightest scientific contribution as a major advance. Public relations practitioners have an apparent compulsion to do this.

It is perhaps fair to say that in the hierarchy of the intelligence, only the perceptive individual has the capacity to recognize what is meant by creativity. Most of us wish to think of ourselves as creative, but by this we generally mean that we are clever. True creativity is not cleverness. It is the specific capacity to bring together seemingly dissociated observations into a single concept, from which predictions can be made about events regarding which nothing is known. Creativity in the largest sense is abstract. It is not concrete; it is not a matter of building an icebox or a television set or an automobile with more lights on the tail fins; it is not involved in the isolation of a new virus, or in the production of a new vaccine. It does not consist in assembling ingredients to make a new vitamin tonic nor in putting together component parts to make a new automobile.

Creativity is the product of the highest form of intellectual effort. It is an integration of seemingly dissociated and isolated ideas into one all-encompassing generalization. Creativity is reflected, and brilliantly so, in the work of Einstein, the creation of the special and general field theories of relativity. Creativity was manifest in the mass-energy equation, though not particularly in the resultant development of an atom bomb and a hydrogen bomb. Creativity was shown by Gibbs when he created the laws of thermodynamics. It was manifested by W. Heisenberg when he enunciated the principle of indeterminacy.

Technological development in its entirety is a natural and largely routine evolution from the conceptual roots of true creativity. What is often termed creativity is this kind of development at a very high level. Many—in fact most—Nobel prizes are given not for creative achievement but rather for a high type of technological achievement. I do not wish to deprecate in any manner the merits of technological development. I am only endeavoring, however, inadequately, to urge a realization of the tremendous importance of creativity. The future belongs to science and the nation with the best science will dominate the world scene. This depends on just one thing, and that is creativity.

I had the pleasure of discussing this problem with Professor Einstein shortly before his death. I asked him if anything could be done to improve the situation, and he replied that he did not believe so. He said that he thought a situation might be created in which the possibilities for creative activity would be greater, but he emphasized that individual creativity is a unique unknown quality which cannot be brought into existence by any known mechanism.

THE second step toward correction of the unfortunate dearth of creativity in the United States depends on a consideration of environment. The American scene is not properly attuned to creativity. American educators are in general keenly aware of this.

The youth of the nation is constantly exposed to what has become the supreme glamor of athletics. No one can deny the merit of sports when they are given their proper prominence in the total situation. But a national obsession with sport at the expense of the development of the intellect is surely out of balance. The youth of today is constantly exposed to the earning power, the fame of the star athlete. He is prone to be impressed.

Materialism in the United States is at an all time high. The significance of the individual in society appears to depend not on his creativity but on his bank balance. Ostentatious cars, two-car garages, three-bathroom houses, color television, are the absurd symbols of social acceptability. The entire orientation of our social system is toward material acquisition, and the younger generation is naturally so oriented. Most of us can remember the time when a wrist watch as a graduation present from college was highly regarded, but today nothing short of a convertible is much esteemed.

A further adverse environmental factor today lies in the cultural passivity of a generation of parents who subsist on television and rarely read a book. I have among my acquaintances, as I am sure you have among yours, people who have not read a book

for years. On the other hand, they can give you the precise hour when any program you might name appears. The family eats dinner in front of a television set, thus obviating the need for conversation. Participation even in normal social intercourse has been replaced by passivity. There can be no question but that this environmental trend is a serious hinderance to creative activity. It may be difficult, if not impossible, to correct this situation, but the problem must be dealt with if American thought is to continue to be productive.

THE atomization of knowledge is a third major problem which must be recognized and dealt with by educational means. The tremendous growth of knowledge has perhaps fostered this compartmentalization, which is nevertheless to be deplored. Today, no one is considered, or considers himself to be, for example, a biochemist, on the basis that the field is so broad that it is impossible for one individual to have at his command all the detailed information available. Our entire academic world concerns itself with details. Our scientific meetings and journals concern themselves with details. So a scientist has a detailed field; he is an enzyme biochemist or a physical biochemist or a biochemical physicist, but not, save the mark, an unalloyed biochemist.

All this is deplorable—not in itself, since consideration of details is essential, but because it eliminates any tendency toward synthesis. Because the educational system to which I was subjected was concerned with detail, I studied human anatomy in three separate courses under three separate sets of circumstances. First as an undergraduate, then in graduate school, and finally in medical school I studied the human body from top to toe and from side to side. Of the multitudinous details which were drilled into me remorselessly I remember a small percentage. When I want detailed anatomical information I look it up in the library. This gives me a sense of exquisite justice, since I am quite sure that this is what my anatomy professors did immediately before their lectures. And I think that my fellow students and I would have been much better trained had the time allotted for the acquisition of soon-to-be-forgotten detailed knowledge been spent in synthesizing and correlating a relatively few basic facts.

THIS I believe leads naturally to the fourth point which I wish to make—that more emphasis must be placed on integrative thinking. The ability to integrate observations and then to generalize is at the same time the hallmark of creativity and that of genius. The study of the stepwise development of the great scientific concepts by these orderly procedures would be of inestimable value in training our students for real achievement. The concept of knowledge for its own sake should be expanded to include the thought that no fragment of knowledge can be regarded as significant until it has been incorporated into, and assigned its proper place in, the over-all framework of the total, ordered, universe.

With this approach, and this approach alone, can it become possible to transcend the limitations imposed on us by the imperfections in investigative methodology. It is apparent, for example, that the living cell as we know it far exceeds in its totality the sum of its component parts. Only by the integration of all our knowledge of the cell—its components, its neighbors and its relationship to the whole—can we hope to understand its fundamental nature.

Implicit in this is the idea that integration cannot be confined to facts within one scientific or aesthetic discipline. Essentially, chemistry cannot be dissociated from physics, physics from philosophy, philosophy from chemistry. Each problem must be considered beyond the limits of a specific field, and beyond the limits of specific methodology. New methodologies will be evolved, but they must be used as tools for, rather than limitations on, the human intellect. Prescientific contempt for the value of observation has been replaced, in a sense, by a contempt for anything beyond a rigidly circumscribed mass of details. The abstractions of science, and the possibility of extrapolating largely from science, have been overlooked. Like the cell, science should be considered as a part of a whole rather than as an infinite assemblage of detail.

This, I believe, although it may represent a change in our standard of values, is the road to true creativity. But before we can set our feet on this road, we in the United States must recognize the significance of creativity and our need for it. Only an appreciation of the necessity for this type of thinking will enable us to hold our place as a world power, and indeed, perhaps, to survive.

THE HEALTHY PERSONALITY

William M. Nicholson

A Report by a Clinical Psychologist of the Increasing Emphasis on the Concept of Psychological Health

PSYCHOLOGICAL health has aroused a great deal of interest, particularly in more recent years, and there is an ever-increasing tendency towards the investigation of psychological health and creativity to replace past emphasis on abnormal psychology. At the National Convention of the American Psychological Association, Dr. Ann Roe was chairman of a symposium on the "Concept of the Healthy Personality" on September 3, 1957. Articles for the occasion were by Dr. Carl Rogers of the University of Wisconsin, Dr. Gardner Murphy of the Menninger Clinic, Dr. Leslie Phillips, Worcester State Hospital and Dr. Robert W. White of Harvard.

Dr. Rogers spoke as a client-centered therapist who based his conclusions on having observed what constitutes "growth" in therapy and the attainment of freedom which was previously lacking in the individual. He emphasized strongly that psychological health is not a static state of achievement or happiness or adjustment. The healthy life is a dynamic process, a state of flow. It is a direction in life, a direction selected by the total organism when there is freedom to make choices. The qualities of this direction have a certain universality. A healthy person is open to all experience. Outer and inner stimuli are transmitted without distortion. He is sensitive to his environment, his own inner feelings, reactions, and emergent meanings. "He is more able to listen to himself." He is more open to the feelings of fear and pain within himself, but also more open to courage and awe than other people. He is also quite sensitive to other people.

The healthy person is able increasingly to live fully in each moment and to experience each moment as new. Thus he engages in existential living. The self and personality emerge from experience, rather than experience being twisted to fit preconceived ideas. He has an ability to relinquish complete control sometimes and to let himself go. He does not rigidly seek to have control over events which might well be allowed to occur of themselves.

The healthy person regards his total organism as wiser than his awareness and better able to reach solutions. Because he is open to experience, doing what he intuitively *feels* is right quite often proves to be so. He does not have to rely on guiding principles, codes of action, past experience, authority, etc. The reliance on the total organismic response may seem subjectively or experimentially to be irrational, although it will be perceived from the outside by others as being very rational. It is not illogical, but it may be irrational in the sense that the judgment is nonverbal, intuitional, and does not follow the usual deductive methods of logic.

The reaction of the total organism can be inhibited by two conditions: the inclusion of information that does not belong, and the exclusion of information that should be attended to. The latter is usually the result of anxieties which are a threat to the self, and the individual does not want to look at the data. Thus, a healthy individual can allow himself to be angry in situations because he is simultaneously aware of other desires, such as his desire to be liked, etc. He reacts as a total organism rather than upon anger alone. This could not occur if the individual shuts off other data in the situation. Then anger leads to poor judgment.

From "healthy" individuals comes a greater degree of creativity than we can expect from others. They live more fully in a wider range of emotions, living more intimately with pain but also more vividly with ecstacy. They launch more and more fully into life in order to realize their potentialities. One of the deepest experiences that a patient can have in therapy is the realization of his power of choice when he perceives that his behavior is not completely determined, that the individual is active in creating his own destiny.

Dr. Murphy discussed psychological health in terms of self-realization. Each individual has vast untouched potentialities, and psychological health means fulfillment rather than frustration of these potentialities. The individual chooses the direction which self-realization takes. There is no one specific goal toward which an immature organism strives. There are broad limits, and in biological and psychological terms, it has been shown that the immature organism has several goals towards which it may grow. But there are definite limits, though these are broad.

Dr. Murphy talked about the individual and about the concept of group responsibility. He would like to see more psychological studies of the influence of group life in school on the personality. There has been so much study on home life but almost none on the influence of peer relationships in the formation of character.

Dr. Phillips emphasized the concepts of "Perceptual Constancy" and "Reversibility of Thought." Through the individual's sensory impressions, he achieves a perceptual constancy and is at ease with reality. If he is capable of reversibility of thought, he becomes flexible instead of rigid and becomes free of egocentric attitudes. He becomes sensitive to what goes on in others and how it affects himself, and is more capable of changing himself.

Dr. Phillips mentioned that in the growth of the individual there is a process of changing from diffuseness to differentiation, in which parts of the personality become more specific in their functioning. There is a retrogression and diffusion before a person grows into another "higher" state. The present is becoming subordinate to a higher stage. Thus, regression is not always pathological, but can be done in the service of the ego. Psychopathology refers to a type of regression which is somewhat irreversible and regressive to a lack of correspondence between the internal state and the outside demands.

Dr. White's paper emphasized the importance of "the search for competence or mastery" in the healthy individual. He cited the work of Piaget who indicates that the behavior of children is motivated, directed, and persistant in its exploration of the world. Psychological literature, particularly about adults, has failed to take into account these hidden drives toward mastery. Mastery is itself rewarding, aside from the pleasure of parental approval. The child may obtain disapproval from his parents if he climbs a tree, but there will be a certain pleasure in having accomplished the climbing, even though he dislikes the disapproval.

It is important in the development of an individual that he come to realize that he can influence his environment rather than having to be entirely submissive. It is very important for a child to realize that he influences parents in certain matters, that they are not completely rigid in their attitudes. Evidence shows that if a child realizes that he can influence his parents, the behavior of the parent is less likely to cause trauma even in stressful situations. Dr. White does not deny that trauma may be important in the development of the personality, but he feels psychologists have sadly neglected the importance of experience of success.

All the papers emphasized the freedom of the healthy individual in charting the direction of his life. It appears that the behavior of the healthy, creative individual may be less predictable than that of the neurotic. Freedom of choice has traditionally been opposed to the determinism of science. It has been too frightening to consider that the individual has a choice in creating his own personality and his own destiny because the more choice operates, the less predictable the behavior of the individual might be. But in spite of the lack of predictability of the creative person, psychology is arriving at a "healthier" concept of "psychological health" than in the past.

The Harvest of Anti-Intellectualism

"OUR youth shuns science in resistance against demands for conformity in thinking. The Purdue Opinion Panel's poll of a nationwide sample of high school pupils in 1956 showed a twenty-seven per cent belief that science expects its practitioners to be 'willing to sacrifice the welfare of others to further their own interests,' a fourteen per cent belief that 'there is something evil about scientists,' and a nine per cent belief that 'one can't be a scientist and be honest."

—From "What We Don't Know Hurts Us," by Chauncey D. Leake, Chairman of the Committee on Social Aspects of Science of the American Association for the Advancement of Science, in the January 4, 1958 issue of the *Saturday Review.*

SOURCE READINGS: INTEGRATIVE MATERIALS AND METHODS

The Origin of Life

THE November 2, 1957 issue of *Nature* contains a report by N. W. Pirie of a recent symposium which the International Union of Biochemistry held in Moscow, attended by scientists from a number of different countries, including the United States. The symposium, whose general title was "The Origin of Life on the Earth," was organized by Prof. A. I. Oparin, who has written a book under the same title which has recently been translated into English by Dr. Anna Synge.

Mr. Pirie reports that about sixty papers were submitted and discussed during the session—a truly ambitious attack on the subject. The general tenor of of the meeting is described as follows:

"There is now general agreement that life can arise from non-living matter but there is disagreement about how often it does so. The possible points of view are set out in Table 1:

Table 1. Biopoetic Theories

No. of Biopoeses		General Character
1	None	Life has always pervaded space and an apparent origin is simply a transfer from place to place
2	One	Creation by divine intervention
3	One	Creation on Earth by the action of inevitable, normal processes
4	Several	Repeated coordination of eobionts or subvital units
5	Innumerable	Classical and medieval idea that life appeared whenever there was a suitable environment.

Possibilities 1 and 2 are now not often advocated, but 1 will soon become amenable to experimental test when astronauts set out to look for what Haldane calls 'astroplankton.' Possibility 5 was effectively disproved during last century, not so much by the work of Pasteur as by the existence of the food-canning industry. That leaves 3 and 4. Many people advocate 3 because they claim that the biochemical uniformity of present-day life, and the preponderant use in proteins of amino-acids of only one of the two antipodal series, suggests a common origin. This point of view was maintained at the symposium by R. L. M. Synge; but it does not seem to me to pay sufficient attention to the operation of food chains in Nature. If any group of organisms started to use one antipodal series it would be advantageous for any other group, even slightly dependent on the first, to come into line. And there are obvious advantages in using one series only. Though biopoesis is probably a rare event it is probably not a unique one. Disproof of this point of view will be difficult. It is hard to experiment on rare events and, as Darwin long ago pointed out, any new intruder into the living domain would now be immediately used as food by a longer established organism.

"The Moscow discussion, like most similar discussions, got bogged down from time to time in metaphysics about the nature of life. In spite of official adherence to a Marxist materialist philosophy, a surprisingly large proportion of the Russian participants appeared to be Platonic Idealists. They realized that they could neither define nor unequivocally recognize 'life,' but they were none the less certain that there was such an entity to be recognized. This was also the attitude of many members of the group from the United States. Even the 'cold war' cannot contend with Idealism." The author characterized his own attitude as Empirical Nihilism, which he defined as "holding that the statement that a system is or is not alive is a statement about the speaker's attitude of mind rather than about the system, and that no question is scientifically relevant unless the questioner has an experiment in mind by which the answer could be approached." This attitude is particularly important, he feels, in the study of "borderline" cases, such as the viruses, where exact definition is impossible.

Discussing a number of papers which were based upon the assumption that life can only exist as a result of the activities of proteins, nucleic aids, high-energy phosphates, and so on, Pirie remarks: "Undoubtedly all the present-day organisms that have been studied contain all these substances; they also contain fats, carbohydrates and so on. In these circumstances it seems invidious to pick any one as the *sine qua non* of life. We are not even justified in assuming that there was any single type of substance in this unique position. It is just as likely that primitive forms of life, or eobionts, made use of many different mechanisms, and that the mechanisms we see now are the end result of an immense process of evolution and selection. Proteins may be the most efficient rather than the only vehicle for living. . . . The great difficulty of discussions on the origins of life is that they are attempts to describe events long before the beginning of the fossil record. . . .

"Two courses are open. One is an intensification of geochemical studies, and if they are to be useful it is important that they should not be conceived narrowly but keep all the biopoetic possibilities in mind. The other is to follow the course of evolution backwards to see if the apparent direction, in the period about which we have evidence, can be used to give hints about the period before that. M. Florkin attempted this for aspects of the metabolism of complex molecules, and I did so for some of the elements.

Florkin showed how often a substance that seems perfectly adapted for one role appears in more primitive organisms filling an entirely different one. Thus oxytocin exerts uterine control in mammals, but controls water metabolism in amphibians. Furthermore, as evolution proceeds there is good evidence for biochemical simplification. Haldane, who unfortunately was not at the symposium, has already argued that the only exception to this generalization is protein synthesis, which seems to get more elaborate in the higher organisms. If this is indeed so, and if we follow the logic of the generalization, it suggests that proteins, far from being the original essential vehicles of life, are a relatively recent innovation. The efficiency given by proteins may have made them dominant. . . .

"Argument about evolution presents many intellectual pitfalls for the imprudent. . . . The concept of 'Fitness' . . . leads . . . [to] the proposition that the chemical and physical properties of water, carbon dioxide, etc., are uniquely fitted to give organisms a comfortable environment; and the argument seems plausible until we realize that that is why organisms have evolved with the properties we know. The environment selects those that fit it. It is no accident that the environment suits proteins: had it been different another group of substances would have assumed the dominant role that proteins have in this one. Thus in an environment of liquid ammonia and methane, such as is postulated by some on Jupiter, there would be less need to have macromolecular catalysts, like proteins, because Brownian movement would not be juggling the catalyst's elbow all the time. The reactions there on which life, if any, depends will be slow, but the universe does not seem to be short of time. . . . The basic illusion is to assume that ours is the only way of life."

—E. B. Sellon

The Scientist as Citizen

THE significant and ever-increasing *interdependence* of all departments of life and of all areas of human inquiry becomes more evident the more we think about it. The "scientist" and the "citizen" are not two different types of people, whose lives and activities touch only peripherally and accidentally. A scientist is primarily a person, a citizen, however erudite and specialized his activities as a scientist. The scientist, as a person, is involved with all of his fellow citizens; many of his problems, his hopes, and his concerns are held in common with every man, and there is abundant evidence that men of science are growing in awareness of this fact.

There is less evidence that the average citizen recognizes or realizes his complete involvement with, and concern with the world of science. That such recognition and realization is a virtual necessity, requiring a fresh evaluation of our concepts, has been exoressed clearly and eloquently by Dr. Warren Weaver in an article entitled: "Science and the Citizen" which appears in the December 13, 1957 issue of *Science*. Here are some highlights from this excellent article:

"The atom, the cell, the star—the mind of modern man has invaded all of these. This new knowledge has brought new beauty into life, new satisfaction of understanding, and new power over nature. But it has also brought great and unavoidable problems. Many of these are economic, social, political, and moral problems; but they are also inescapably scientific problems. Thus these are not isolated problems for a few queer specialists. They are problems for every citizen.

"No longer is it an intellectual luxury to know a little about this great new tool of the mind called science. It has become a simple and plain necessity that people in general have some understanding of this, one of the greatest of the forces that shape our modern lives. We must know—all of us must know—more about what science is and what it is not. We must appreciate its strength and value, and we must be aware of its limitations. We must realize what conditions of freedom and flexibility of support must be maintained for pure scientific research, in order to assure a flow of imaginative and basic new ideas. Without some of this understanding we simply cannot be intelligent citizens of a modern free democracy, served and protected by science. Without this we will not know how to face the modern problems of our home, our school, our village, state or nation."

The extent to which our everyday lives are involved in and with the doings of science is pointed up by Dr. Weaver thus:

"Our daily lives are surrounded by problems with scientific implications. When do we—or do we not—consult the psychiatrist or accept a free shot of a new serum? How about vitamins, hormones, sleeping pills and tranquilizers? How about nutritional regimens and slimming schedules? How about the emotional and psychological problems of present-day children? How about birth rates, death rates, population increases and food supplies? How about cigarette smoking and lung cancer?"

These are but a few of the involvements with science which Dr. Weaver lists. But he cautions us that these "practical" questions, important as they are, should by no means limit the challenge to know something more about science. As he points out: "For if we restricted our interests to motors and drugs, to electronic computers and guided missiles, to radiation genetics and atom bombs, we would move step by ugly step towards a mechanized future in which the purpose of our lives would be nothing much more than a rather selfish sort of convenience and safety precariously posited on power. It is therefore of even more basic necessity that we understand the deeper aspects of science—its capacity to release the mind from its ancient restraints, its ability to deepen our appreciation of the orderly beauty of

nature, the essential and underlying humbleness of its position, the emphasis it places upon clarity and honesty of thinking, the richness of the partnership which it offers to the arts and to moral philosophy."

The application of the scientific method to the solution of their problems has led scientists to a general agreement on what Dr. Weaver terms "scientific attitude." He describes it thus:

"One stubborn and complicated problem after another has given way before the evolving techniques of science. These techniques, which sometimes seem so specialized and formidable, with a baffling private language, with concepts of great abstractness, and with instrumentation that not even Hollywood can exaggerate, are in simple fact but highly purified forms of the methods of inquiry and reasoning which *Homo* sapiens has used ever since he first began to become *sapiens*.

"Thus the scientists have learned by experience that it pays to stop and think; that it is sensible to suspend one's prejudices and try to find out what the relevant facts are; that trying to decide what *is* relevant is of itself an illuminating procedure, that if the facts, as determined under sensibly controlled conditions and by competent persons, run contrary to tradition or hearsay or the position of arbitrary authority, then it is necessary to face and accept the story which is told by the facts; that logical precision in thinking is very useful when one is dealing with the more quantitative aspects of experience; that high standards of personal honesty, open-mindedness, focused vision, and love of truth are a practical necessity if one is going to be successful in dealing with nature; that curiosity is a worthy and a rewarding incentive; that nature is orderly and reasonable, not capricious and mad, with the result that it is possible to attain greater and even greater understanding of the world about us.

"These attitudes—usually phrased more formally —just about cover what is ordinarily called "the scientific method." But I have purposely used terminology that, on the one hand, makes it clear that science has no exclusive claim on these useful procedures, and that, on the other hand, should make it clear that persons in all fields of activity ought to inform themselves about the way in which science uses these procedures, since they obviously have validity in many other fields. . . .

"The fact is that the average citizen tends to fear science, when he should, of course, learn about it, so that it can be an exciting intellectual companion and a useful servant. He tends to think that science is entirely mechanistic, and that its successes in the biological field depress the dignity of the inner man; whereas, as Robert Oppenheimer has said, he should '. . . have known that human life was far too broad, deep, subtle, and rich to be exhausted by anything the scientist would find out in his own field' ."[1]

—*Alan Mannion.*

[1] R. Oppenheimer, *Phys.* Today 10, No. 7, 12 (July 1957)

New Light on the Mystery of the Earth's Core

IN the Dec. 7, 1957 issue of *Nature* there appears a summary of a paper entitled: "A Geo-chemical Hypothesis of the Earth's Structure." The original paper was read at the Symposium on Geo-chemistry held in Paris in July 1957, by A. F. Kapustinsky, Corresponding Member, Academy of Sciences, USSR, Institute of General and Inorganic Chemistry, Moscow. *Nature* reports Dr. Kapustinsky as follows:

"In my two papers[1] I have discussed a concept which I have called 'periodicity function'—a mathematical expression, based on empirical data, which shows at what pressure all of the elements are modified to such a degree as to lose their property of periodicity; in other words at what pressure all atoms will become identical in respect of their chemical properties."

It will be remembered that the *number* and *arrangement* of the electrons associated with a given atomic nucleus determine the chemical and electrical nature of any particular chemical element. Chemical operations are those which modify the electronic situation in the outermost (or valence) shell of electrons in a given element. When combining into molecules, elements may lend, borrow or share electrons from this outermost valence shell. Dr. Kapustinsky continues:

"According to my calculations such a pressure will be of the order of 1,400,000 atmospheres, corresponding to a depth of 2,900 kilometers (approx. 1800 miles). Certain works by Ramsey, Kuhn, Wigner, Huntington and others have a bearing on the development of this idea, as well as my own researches on the thermodynamics of compressed crystals, which represent further expansion of the idea of Lewis that the entropy of a highly compressed crystal tends to zero. Thus I assume that at the high pressure prevailing in the 'centrisphere' all atoms will be in a 'metallized' state, in which matter will be made of atomic nuclei immersed in a homogeneous electronic plasma."

A current of electricity is generally conceded to involve a "flow of electrons" through a conductor. Considered very simply, we may imagine that, in a copper wire, adjacent atoms are so placed that electrons can flow or drift from the shell of one atom over to the shell of its neighbor, etc. This drift occurs when electrical pressure (or voltage) is directionally impressed upon the conductor. In the "metallized" or high-pressure state just described, electrons are not associated with any particular nucleus, hence the entire electronic plasma would be electrically conductive.

[1] "Problems of Geochemistry and Mineralogy." Acad. Sci. USSR 37 (1956). "Geochemistry" Acad. Sci. USSR 1, 53 (1956).

"Having no specific electrons attached to them, atoms will cease to be separate elements with definite atomic numbers, definite chemical properties and reactions in this region of 'zero chemistry.' On the other hand, in this state matter will be characterized by such a high electrical and thermal conductivity that the temperature of the whole of the 'centrisphere' will remain constant.

"The geochemical hypothesis of the structure of the earth briefly expounded here requires verification and amplification. It finds support in certain thermodynamical considerations and seems to agree with the seismological data. In any event, such a hypothesis may stimulate further research and point to new concepts of matter."

—*Alan Mannion*

A New Concept of Mathematics Teaching

THE fundamental importance of acquiring new methods of stimulating in students a real interest in mathematics, and an appreciation of mathematical concepts, was emphasized in an article entitled "Imagination + X = Learning," by Helen Rowan, Editor of the Carnegie Corporation of New York *Quarterly* in their October, 1957 issue.

The article discusses the experimental work that is being done at the University of Illinois by Professor Max Beberman and his co-workers, who are trying to develop a realistic approach to learning, based upon what adolescents actually feel and think, rather than upon what is ascribed to them by adults. And they are convinced that adolescents revel in abstraction if they are allowed to play with them without pinning them down. Therefore, rather than asking a pupil to explain the tricks which he sees numbers perform, Beberman and his colleagues discourage verbalization as long as they can without frustrating creative curiosity. Non-verbal awareness is, they feel, preferable, because the language of mathematics is most exacting and can be mastered only gradually through an initial intuitive appreciation followed by long and patient practice. If a child is offered some tantalizing relationships, and if he is encouraged to guess the whyfor—as Beberman pupils are—he begins to formulate the underlying principles of mathematics for himself, in his own ingenious and sometimes ingenuous language, instead of waiting to hear them pronounced by the teacher in words that inevitably bear the unwelcome sound of laws fixed by grownups.

This searching for the "why" instead of the "what for" is the mathematician's search for pure knowledge. Miss Rowan writes, " 'Why?' is a question which too often atrophies and dies after we leave adolescence behind. Adults who were never freely exposed to math's fascination while they were at the susceptible age—that is, most of us—are far more likely to ask, 'Of what use it it?' This is the question which all scientists, not merely mathematicians, will recognize as the great 'practical' barrier to appreciation of fundamental research. Professor Beberman may open a broad new avenue for the teaching of all science through his observation that when children ask 'What use is it?' they don't really mean it. The brightest pupils never raise the question."

Beberman's method is currently in use in a dozen schools, teaching some seventeen hundred high school children, but a great many more schools and colleges have expressed their interest in joining the experiment. Because an entirely new teaching method is involved, teachers who participate must be especially trained during special sessions taking place at Urbana, where the project was launched in 1951. After returning to their respective classes, teachers have the continuing benefit of face-to-face consultation with the Illinois staff. In addition, each participating teacher writes a weekly report on his class's (and his own) progress. These observations suggest constant revision of the text and provide a practical leavening of the theories and concepts which Illinois' mathematicians would like to see taught.

The *Quarterly* reports, "What comes out in the end is more a change in emphasis than in content. Along with that goes a change in the traditional sequence in which high school math is taught. A full four-year course used to begin with one year of algebra followed by one year of plane geometry followed by another year of algebra followed by a semester of solid geometry followed by a semester of trigonometry. . . . Under the Illinois system pupils follow threads of arithmetic and algebra and geometry all through, and so develop a feeling for the essential unity of all mathematics. . . .

"The most pervading mathematical idea that the Illinois experiment tries to propagate is the concept of sets. Sets in themselves are old, but their presentation as a point of view is new. A set is any collection of things. The things can be number, points, lines, vectors, physical forces, people, or a set can be a philosophical notion such as brotherhood. By thinking in terms of sets, children learn to see apparent relationships, discover hidden patterns, and invent new arrangements to meet new problems. Having evolved this habit of thinking, they forget the details and retain a mental discipline which can be useful in . . . advanced modern mathematical techniques. . . ."

Teachers of the Illinois method are almost unanimous in saying that, although it is more fun to teach math this way, it is also much more work. It requires some creative effort, not just teaching by rote. The *Quarterly* report indicates that this experiment, as yet limited in extent, and financed by an original in-

vestment by the University of Illinois and a subsequent grant from the Carnegie Corporation of New York, should have far-reaching implications.

New events of the last few months have stimulated interest in science and mathematics teaching. But it would be a great pity if the concern of the nation exhausted itself in short-term measures. As John W. Gardner, President of the Carnegie Corp. says, "Sensible people will bear in mind that in the long run our answer and our hope must be an intensified effort to create in this country a vigorous, excellent, well-rounded educational system at all levels, a strong and well-supported effort in all fields of fundamental research, and a deep-rooted respect for the life of the mind."

Experiments at the conceptual level, like that of the Illinois group, will do more to insure us the kind of educational structure we need than any amount of new buildings or extensions of old-line teaching. When these new developments at high school level are prepared for properly in kindergarten and primary school (a task the Cuisenaire materials are designed to perform), gains will be certain.

—E. B. Sellon

NEWS AND NOTES

THE educational process is governed initially (and all its later course is influenced) by a primary, inescapable circumstance: the infant learns first by imitation, and if this goes on in an atmosphere of happiness, interest and security, a prodigious unself-conscious unfoldment of the human potential takes place. Toward this phenomenon various attitudes are assumed, determined by the philosophy that governs the parents, the teacher and the school system. A dismaying diversity of opinion is apparent: that the child is "just an animal," a *tabula rasa,* a soulless creature to be trained, a mechanism to be conditioned, and so on. Whatever the interpretation, the truth remains that skills and activities of *major* importance are called out at the start. In early years the child *does* first, and learns and can be taught thereby. Therefore the future turns on what transpires in approximately the first seven years. If the thoughts and feelings then evoked are correct, then something is engendered so fundamental that it can be worked over consciously, and thus grow into cultural resources in the youth and adult.

If, for example, language is acquired eagerly and idiomatically from loving parents and others, then grammar and literature can follow as fascinating depths to an already acquired art. Again, singing can be happily experienced and used by very young children. If this can be done, the reading of music, study of its structure and creative exploration of its fathomless meanings can ensue as a delight and a wonder. The child's participation as a singer begins in the earliest years, and when he hears good music, he is, without knowing it, experiencing the whole. Beauty has possessed him. It is obvious that the responsibility of parents is thus primary. If they do not nourish the child's cultural potential, irreparable harm has been done. It is equally obvious that the scenes and sounds of violence, meretricious art, low-grade humor, emotionally destructive music and the like, which are now poured upon families, are social disorders of increasing compulsion.

Turning from language and music to mathematics, it is notable that methods and materials have failed to evoke a delighted interest in and consequent acquirement of mathematical concepts in childhood. There have long been simple materials available for play, which incidentally conveyed elementary ideas of numbers and a few operations. Some of these are chiefly mnemonic devices conjoined with rote, drill, disciplinary training and so on. Narrative texts with cheerful colored illustrations, and enticing examples of arithmetical problems are in use. But up to now nothing has been available to measure up to first needs in mathematics, as singing or speaking have served as introductions to music and literature.

The teacher has hitherto had two choices: Disciplinary instruction, through drill and memorization,

in which operative skill is gained too often at the cost of understanding. Or, various toys and playthings employed to introduce certain arithmetic ideas and terms in the effort to instruct without engendering that distaste for any subject which is made both compulsory and uninteresting. Up to now the teacher has not had materials which embody the priceless element of free play and of free participation, and which yet, *by their very nature,* evoke through enjoyment the great basic concepts and feelings which run all the way through mathematics, just as pitch, key, beat, tempo, rhythm, melodic line, contrapuntal texture, harmonics, orchestration and the like can appear and be experienced in music from the very beginning of its study.

With the appearance and use of the Cuisenaire-Gattegno mathematical aids, these deficiencies will now end. The basic notions of equality, congruence, sets, commutativity, etc. can be experienced and recognized in the same spirit of natural discovery by the child between the ages of four and seven as the basis of music can be put to use by a sudden impulse to sing. What has too often been obscured and even destroyed in myriads of children by blind rote and boring routine can now be prompted in a few interesting hours of happy play.

In view of the crisis in this country over the teaching of science and mathematics, the material described in Dr. Gattegno's article is certainly of more significance than a mere class-room development. It is news of national importance, to be especially welcomed and made known by the National Science Foundation, the National Academy of Science and inquired into by the National Education Association. The mere news that this long-standing problem can now at last be solved should be heartening to all, and the introduction of the materials into schools and homes constitutes something concrete which can be done.

The new materials were devised and have been used for some twenty-five years by Georges Cuisenaire, Directeur d'Enseignement, Thuin, Province of Hainault, Belgium, where they were used within the restrictions of elementary teaching, as confined by the limits of the Belgan curriculum. In 1954 Dr. Caleb Gattegno of London University was asked by the Belgian Government to evaluate the method, with a view to its more general use. Dr. Gattegno is not only a university teacher of mathematics, but also a qualified educational psychologist. He recognized the uniqueness of the material and took the method back with him to England. What was formerly a device to aid in teaching a subject somewhat formalized in a given curriculum, was now to become a fully flowered method, psychologically rich, and applying to algebra as well as to arithmetic.

Later that year, the London *Times* Educational Supplement (November 19, 1954) reported not only upon the demonstrations in the school at Thuin, but also much diversified experience that had been gained by teachers in many schools in England:

"We are confronted, for the first time, with an outstanding solution of the difficulties met in the teaching of arithmetic, a solution for which the exceptional teacher is not prepared but which nevertheless is truly operative. . . . Since we must teach arithmetic to all children, it is a satisfying thought that it can now be done pleasurably and efficiently, and that we can eliminate frustration in a subject which has for generations challenged the minds of teachers."

Now, when it is so urgently needed, a new tool whose use promises a revolution in mathematics teaching is thus most fortuitously available to American education. The fact that the Cuisenaire materials have been in use (in a restricted way) in Belgium for twenty-five years, and in England and elsewhere from five to three years, scarcely noticed in the U.S.A., suggests that many valuable new developments may well be hidden away in scattered schools and should be made known. It is a function of MAIN CURRENTS to serve as a center for exchange. Reports of such are solicited, as well as inquiries about the Cuisenaire materials and method.

—F. L. Kunz

ANNOUNCEMENT may now be made of the visit to the United States—mid-March to mid-April, with possible extension—of a teacher thoroughly experienced and wholly self-convinced in classroom use of Cuisenaire materials: Miss Vina Pow, of Ballainlay School, Bute, Scotland. After many years of teaching with all kinds of hitherto available aids in the United States, England, and elsewhere, Miss Pow began a searching three-year test of the new method, conducted by her personally with classes of children of suitable age, four to seven years. She also discussed progress closely and repeatedly with others using the material, at many meetings and demonstrations of teacher associations in Great Britain. She has now fully established to her own satisfaction the unique efficacy of this approach, and it has taken central place in Ballainlay as it has in other schools in the British Isles.

On her arrival in mid-March Miss Pow will be available first in the New York City and Washington, D. C. areas, and requests for assignments of time in those two regions should be made as promptly as possible, addressed to the Foundation for Integrated Education, 246 East 46th Street, New York 17. If time allows, Miss Pow may visit one or two centers as far west as Chicago.

In writing, please bear in mind that children between four and seven are called for, give the ages and numbers available, the numbers of observers proposed and whether teaching or supervising and in what capacities in the school. Inquiries about Cuisenaire-Gattegno teaching aids will be relayed to a center now being established for supplying the colored rods, teachers' manual, children texts, auxiliary games, geoboards, film strips in color and explanatory text.

REVIEWS

The Measure of Our Universe

THE exploration of the universe involves investigations of both the smallest units that can be measured within the atom and of the largest aggregates that can be measured within the starry heavens. The limits of comprehensible knowledge that can be gained with tools and techniques now available have just about been reached in both directions. Incidentally, it now appears that as far as the magnitudes of dimensions are concerned the human body is approximately midway between the smallest "particles" known to the nuclear physicist and the largest organizations of matter recognized by the far-ranging astronomer.

In the mind-stretching book, *The Inner Metagalaxy* (Yale Univ. Press, 1957, XIII, 204 pages, 59 figs., 17 tables, $6.75), Harlow Shapley brings together the results of three decades of astonishing studies of the large gravitational systems of stars, designated as galaxies, and presents a census of the galactic "populations" in that portion of the metagalaxy which is in the "neighborhood" of the earth. The metagalaxy, of course, is the total recognized assemblage of galaxies and "includes also whatever there may be in the way of gas, particles, planets, stars, and star clusters in the spaces between the galaxies. It is essentially the measurable material universe."

The "neighborhood" with which this book is concerned, is that portion of the space around us which is within a distance of 150 million light years. To the astronomer this is just a relatively small locality. There is no doubt that superluminous galaxies at a distance of a billion light years have already been photographed. It is, however, so large a region and so much has been learned about the matter it encompasses that we can now "discuss with confidence most of the outstanding features of metagalactic structure." Indeed, Dr. Shapley takes justifiable satisfaction from the fact that men have been "able to derive, from our awkward position near the edge of one dusty spiral [the Milky Way galaxy], a fair picture of the whole universe of billions of galaxies," even though less than a dozen of those billions are within a million light years.

Details concerning apparatus used in the surveys—the cameras, telescopes, spectroscopes, photoelectric photometers, etc.—and the personnel at various observatories, as well as somewhat of the cosmogonic theory and magnitude standards on which interpretations of distances and dimensions depend—are set forth. Here, too, may be found statistical data, often in tabular form, such as would be expected in any report of any census. But for the readers of MAIN CURRENTS it is appropriate merely to summarize the major conclusion that may be derived from such a report of a continuing investigation.

The basic question to which this reviewer hoped to find an answer in this book is simple but of great significance: is there an orderly arrangement of galaxies within the universe that might be comparable to the orderly organization of subatomic entities within the atom? The answer is neither a definite yes or no. One could hardly expect that the orientation in space of distant galaxies, of which very few are precisely spheroidal, is gravitationally controlled, nor is it likely that there are vestiges of any "original" orientation. "Nevertheless, improbable as it may seem, there is growing evidence of deviation from randomicity in the orientation of galactic planes."

In a somewhat similar vein, the distribution of galaxies in metagalactic space appears to be quite uneven. This might be due to nonuniform intervening light scattering or to clouds of absorbing material although "extragalactic absorption of sufficient density seems very likely." It is the tentative conclusion that the apparently uneven distribution of galaxcies indicates the nonhomogeneous structure of the metagalaxcy, but Dr. Shapley ventures no speculation as to what that type of structure might imply.

Finally, it is observed that "the evolution [of galaxcies] is toward smoothness of structure." This development of a galaxy is "an inevitable result of its stars shining away their masses and of its varied speeds of rotation dissolving its loose clusters and star clouds. . . . We should not, however, be too confident that this is a one-way process. . . . Galaxies can grow in mass by accretion while they decay through radiation, and the two processes may be more nearly in balance than now is believed."

Very evidently, "mighty operations are going on." We may be sure that astronomers will not rest content until they know much more about those operations than they do today. The fast photographic emulsions, the wide-field, highspeed cameras, and the radio telescopes now coming into use are certain to open a new epoch in metagalactic surveying.

—*Kirtley F. Mather*

The Dynamics of Change

PROFESSOR Sorokin has abridged his four volume classic, *Social and Cultural Dynamics,* into a single volume, and has brought the argument over the twenty intervening years up to date. (Porter Sargent, Boston, 1957, 704 pages, bibliography, index, $7.50.) We shall thus have at hand, for years to come, the essence of the matter.

In this case, the mere announcement of publication is enough. The volume is quite unique. Nowhere between two covers can so complete a documentation of change be found. On its opening page it raises boldly *the* issue: "Is every culture an integrated whole, where no essential part is incidental but each is organically

connected with the rest?" Then it marshals what today is known to bear on the answer. The author realizes full well that the *actual* structural principles of social organization in terms of nature and of man have not yet been discerned, as principles of reality have been found out in (for example) crystallography. But better possibly than any man alive today, he is in a position to believe there are such principles, and that they can be found. He can be counted among those who know precisely how to go about the finding.

Thus we may say that, at this moment, the book we are noticing gets its *urgent* importance as a lead to the author, (and we say this most seriously) who is a notable part, along with others, of one of this country's most important natural resources: the people with the scientific and philosophical penetration into our current problems.

Recent events have made it clear that what we now need is insight, courage, and forthrightness. By insight, we mean ability to trace scientific and social processes back to reality. Political- and economic-minded persons in places of power have relied upon management, public relations, sentiment, and arid fact-finders, operating at descriptive levels. They have not only neglected the genuinely creative and bold social-philosophical minds: they have tried to ignore and even to cow them. We fund Congress generously, arm it quite properly with dangerous powers, and rightly armor its members with legal immunity. The time has come to find, to free, and to fund men who can understand, explain, and set-going those processes of adult and formal education that will enable the Congress to do its work. Millions are locked up in funding foundations which are forbidden to "influence legislation." Thus even those foundations which would like to help the Congress in what matters can do little, while lobbyists continue their work, in the dark.

But the Congress has voted billions of its own (our own) money, for basic research and better education. It does this, really, because "changes in major systems" of society (including our society) are proceeding, and we are falling behind. Where will Congress get the answers? They cannot be got from electronic computers, nor from mechanistic minds. Let us put men like Sorokin to work on both aspects of the problem: (1) How did we get to know the reality about (say) crystal organization? (2) How do we go on from there through biology to society? If we fail to do this, then the crisis that is mounting will come to its peak when we pass to that inevitable new state of peacetime economy of abundance—and find our education has proved unequal to the task of saving this democracy.

—*F. L. Kunz*

Two Different Approaches to an Educational Metaphysics

THE timeliness and enduring value of *The Ideal and the Community,* by I. B. Berkson, Professor of Education at City College, New York (Harpers, 1958, 293 pages and index, $4.50) consists in its careful and rich summarizing, for this generation, of the educational philosophy and outworkings of Dewey and Kilpatrick (Part 1), and then a searching analysis of experimentalism as inadequate, falling ill-defined between empiricism and experientalism. We are then offered a discussion of the pragmatism of Pierce and James, as representatives of rational philosophies and of provisional cosmologies based upon beliefs which must come in at the start—all sciences postulate orders, many of them hypothetical—and must appear (as extrapolations) at the end, since we know so little. Professor Berkson is now in a position to formulate not his personal views alone nor, indeed, at all, as if he had the answers, but to assess the situation, as it now is. Of course his views emerge, and are clearly put. But the volume is a masterly assembling of the people—for example, on pages 82 and 83, Cassirer, von Nexküll, Santayana and Wolfgang Köhler are all cited tellingly to one and the same point—and of the principles indispensable to the argument today, from Western sources.

Of his own view, the author says: "My position denies the validity of basing education on a metaphysical principle or on an abstract social conception. A philosophy of education involves the correlation of an ethics with a politics: it must be formulated on the basis of a definite pattern of values conjoined with a specific system of social and economic institutions. In my view the pattern of values which provides the ground and the goal of the educational process is found in the historically developed culture of the Western world. The philosophy proposed reflects a high regard for the social heritage as the reservoir of our values. It is at the same time pervaded by the consciousness that we are entering a new epoch in civilization — one pregnant with opportunities for humane achievements as well as fraught with the possibility of irremediable catastrophe."

Far too little is said about the fact that modern physics re-opens metaphysical issues afresh; about pre-Periclean, and hence Eastern, contributions; about the need for educational research along these and related lines—for example, into what Northrop calls concepts by intuition—to get out of this restricted domain. By reason of the quality of his thought, his mastery of the materials, and the candor of his expression, the author puts the unusual reader in a position to understand where we are. He does not take us further. Very few of the younger men in the philosophy of education go further; but few, if any, have put the contemporary situation in anything like these incisive terms.

THE *Organic Philosophy of Education,* by Dr. Frank C. Wegener, Professor of History and Philosophy of Education, University of Texas (Wm. C. Brown Company, Dubuque, Iowa, 1957, 460 pages and index, $6.00) turns upon Whitehead. In fact there is a useful glossary of about sixty of Whitehead's chief terms (pages 453-460). The shadows of Dewey fall over many pages, his almost unmanageable ecelecticism lending him to causes (such as serious Platonism, herein) which Dewey himself can scarcely be said to have explicitly espoused as centrally significant.

In contrast with *The Ideal and the Community,* here is an earnestly written book, applying a central doctrine to schooling. The writing is simple and clear, but in the earlier chapters we are working far too much at descriptive levels, and authors are cited in that same style. Thus Professor Mortimer Adler and Jacques Maritain are quoted on the order of knowledge and

the order of learning (pages 271-272), but Dr. Wegener makes no effort to show that what the quotations say in learned language is commonplace, or to bring forward (as germane to his own thesis) what both men imply about the nature of the child's potential: that the child is prompted by praxis to generate both inductive intuitions and unschooled deductive generalizations—again Northrop's "concepts by intuition." It is not until we get to page 288 that we feel that we are getting the benefit of the author's own life in education and his insight into Whitehead.

A great number of teachers will find Dr. Wegener's book invaluable. We put it gratefully on our own shelves, within close reach.

THE two volumes noticed and contrasted above do more than embody for us in summary form in each case a lifetime of study and endeavor. Their simultaneous appearance and complementary nature bring us back once more to the deplorable, inexplicable neglect to establish a center in which the philosophy and metaphysics of modern science can be articulated, as a proper part of the whole. This point bears repetition, over and over. The slackening off of the so-called unity of science movement, which embodied at least hopes in this direction, and dealt with good science, whatever authority its philosophy may have had or not had, makes the chasm the more obvious to anyone who looks honestly at the American educational scene.

Let us suppose that an institute for integrative studies had been long adequately staffed, equipped, and endowed for long-range performance. Would not the two authors, whose books are noticed above, have had a source from which both could have drawn a common fund of concepts indispensible for their purposes? Would not their necessary divergences and emphasis have been all the more stimulating if each had had to give account of the same highly authoritative material?

In a recent issue of MAIN CURRENTS (November, 1957) the point was made editorially that the Fund for the Advancement of Education has once, at least, indicated its awareness of the problem and the need for action. Such action not being thus far in evidence, as far as we know, it is doubtless fair to assume that no properly scaled and methodologically sound educational program will be forthcoming from that quarter. But new forces are now released. That Fund, or some other, is certain to be discussing anew what must be done if our teachers are to have, in a climate of freedom, what the Russian system gives its professional people in a climate of purposeful regimentation. We cannot go on forever supposing that the improvement of the life of the American car is an adequate substitute for improvement in the life of the American mind.

Are not teachers of the history and philosophy of education finally more responsible than any other professional group for the long-continued failure to attack this problem unitedly? They have their special organizations. Perhaps we are all *over-organized,* and this is part of the failure to act. Yet certainly if two or three of these groups were to formulate a program of research along integrative lines, in which a valid, public, richly documented, and illustrated philosophy of today's science were essential but not exclusive, surely one or more of the longer established funding Foundations would now act? At last the American people are aroused sufficiently about the intellectual and moral weakness of a system that—as a system—has latterly ranked things above people, even though—as individuals—the people who serve the system would deny indignantly that such has been the fact.

After all, teachers of the philosophy of education should assume a major responsibility for American attitudes. It may be presumed that they should affect every classroom and every teacher. In teachers' colleges they do this in some special measure. The thinning shadow of John Dewey's eclectisim nevertheless lingers over the land. But gifted and courageous as he was, was Dr. Dewey such a genius that a whole nation should be so powerfully influenced by him? Did he not bulk large partly just because the philosophy of science had no central place where its contribution could be direct and clear, not interpreted by some one man or small group, however gifted?

As long as there is no center for integration, the void will be filled somehow by arbitrated opinion, and authoritarianism of one or more kinds will continue to have powerful effect. This may include the authoritarianism of so-called practical men, "the facts of life," economic necessity, political force, and propaganda. Even blank avoidance of basic issues, mixed with high moralism, may become a force just because everybody reads his newspaper. —*F. L. Kunz*

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